

EXHIBIT 17



The Development of Long-Term Adverse Health Effects in Oil Spill Cleanup Workers of the Deepwater Horizon Offshore Drilling Rig Disaster

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Background: The purpose of this study was to assess the long-term adverse health effects of the 2010 *Deepwater Horizon* Gulf oil spill exposure in workers who participated in its cleanup work.

Methods: Medical charts of both the oil spill exposed and unexposed subjects were reviewed. The changes in the white blood cells, platelets, hemoglobin, hematocrit, blood urea nitrogen, creatinine, alkaline phosphatase (ALP), aspartate amino transferase (AST), alanine amino transferase (ALT) levels, as well as their pulmonary and cardiac functions were evaluated.

Results: Medical records from 88 subjects (oil spill cleanup workers, $n = 44$ and unexposed, $n = 44$) were reviewed during initial and 7 years follow up visits after the disaster occurred. Compared with the unexposed subjects, oil spill exposed subjects had significantly reduced platelet counts ($\times 10^3/\mu\text{L}$) at their initial (254.1 ± 46.7 versus 289.7 ± 63.7 , $P = 0.000$) and follow-up (242.9 ± 55.6 versus 278.4 ± 67.6 , $P = 0.000$) visits compared with the unexposed subjects (254.6 ± 51.9 versus 289.7 ± 63.7 , $P = 0.008$). The hemoglobin and hematocrit levels were increased significantly both at their initial and follow-up visits in the oil spill exposed subjects compared to the unexposed subjects. Similarly, the oil spill exposed subjects had significantly increased ALP, AST, and ALT levels at their initial and follow-up visits compared with those of the unexposed subjects. Illness symptoms that were reported during their initial visit still persisted at their 7-year follow-up visit. Notably, at their 7-year follow-up visit, most of the oil spill exposed subjects had also developed chronic rhinosinusitis and reactive airway dysfunction syndrome as new symptoms that were not reported during their initial visit. Additionally, more abnormalities in pulmonary and cardiac functions were also seen in the oil spill exposed subjects.

Conclusion: This long-term follow-up study demonstrates that those people involved in the oil spill cleanup operations experiences persistent alterations or worsening of their hematological, hepatic, pulmonary, and cardiac functions. In addition, these subjects experienced prolonged or worsening illness symptoms even 7 years after their exposure to the oil spill.

Keywords: blood disorders, cardiac toxicity, chemical exposure, crude oil spill, dispersants, health impact, hematological toxicity, hepatotoxicity, pulmonary toxicity

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In our previous study, we reported early clinical findings among the workers involved in the oil spill cleanup operation (30). In this follow-up study, we have evaluated the long-term effects of this oil spill exposure among those participants involved in its cleanup activities 7 years after their exposure. To the best of our knowledge, this is the first and only longitudinal study that has evaluated any of the long-term hematological or hepatic adverse health effects of the Gulf oil spill among those subjects involved in its cleanup activities 7 years after the disaster. In addition, this study has evaluated the long-term illness symptoms and complaints, as well as pulmonary and cardiac functions seen in the oil spill exposed cleanup workers (30).

Assessment of hematological markers such as WBC counts, platelet counts, hemoglobin, hematocrit, BUN levels, etc. are routinely used to diagnose a variety of human diseases including malignant tumors. The findings of this longitudinal study performed 7 years after the occurrence of the oil spill disaster shows that subjects who had participated in the cleanup activities had altered profiles of their hematological and hepatic functions when compared with those of the unexposed subjects. More specifically, the oil spill exposed workers had persistently increased mean WBC counts, hemoglobin, hematocrit, APS, AST, and ALT, and reduced platelet counts as well as BUN levels even 7 years after the oil spill disaster. The findings of this study support our previous study findings in which we reported that those workers who were exposed to the oil spill during its cleanup operations had significant hematological and hepatic alterations (30). Another important finding of this long-term study is that most workers have now developed chronic rhinosinusitis (91%) and reactive airway dysfunction syndrome (45%) as new symptoms up to 7 years after their oil spill exposure. These symptoms were not routinely reported during their initial visit which occurred soon after their oil spill exposure. There are no existing studies in literature assessing the long-term human health effects of an oil spill exposure on the hematological, hepatic, pulmonary, or cardiac functions to compare with our study findings.

The long-term effects of the BP oil spill on exposed cleanup workers produced an increased prevalence of illness symptoms such as shortness of breath, headaches, skin rash, chronic cough, weakness, dizzy spells, painful joints, and chest pain 7 years after their exposure to the oil spill. Previously, several studies have likewise reported an incidence of acute somatic symptoms in oil spill exposed or oil polluted subjects (8, 23–26, 35, 36). However, one study by Zock and coinvestigators (28) assessed long-term respiratory symptoms in cleanup workers 5 years after their exposure to the Prestige oil spill. These authors reported that the oil spill exposed workers had persistent respiratory symptoms including shortness of breath, wheeze, cough, and phlegm 5 years after their exposure to the oil spill (28). The findings of the long-term persistent respiratory health effects of the Prestige oil spill exposure support our study findings. The results of our study further reveal that intensive participation even for short periods (only few weeks) in the oil spill cleanup work activities has resulted in persistent long-term adverse health effects. The Gulf STUDY which is a prospective study designed to investigate the relationships between oil spill exposures and multiple potential physical and mental health

effects may shed more light on the long-term adverse effects of oil spill exposure in affected populations (37). The Women and Their Children's Health study has been designed to evaluate the mid-term to long-term physical, mental, and behavioral health effects of the oil spill exposure (8, 38).

In general, an oil spill is composed of a complex mixture of multiple toxic chemicals; its exposure can cause respiratory illnesses and impairment of pulmonary functions (39–41). Therefore, we assessed the pulmonary functions in the oil spill cleanup workers during their initial and later follow-up visits. Our findings indicate that the incidence of deteriorated pulmonary functions had increased over twofold from their initial visit ($n = 7$) to their later follow-up visit ($n = 18$) 7 years after their exposure to the oil spill. The moderate-to-severe pulmonary function abnormalities were more common 7 years after their exposure to the oil spill. Although the precise mechanisms of how the oil spill exposure may have caused impairment of their pulmonary functions are not precisely known, we believe that it is in part due to the exposure of the toxic chemicals found in the crude oil mixture, and their caustic effects on the pulmonary parenchyma during inhalation of the vaporized organic molecules.

Previous studies have shown that oil spill exposure can affect cardiac function in birds (32) and fish (33, 34). Therefore, we evaluated the cardiac function in the oil spill cleanup workers. We found several types of abnormal cardiac functions in those workers involved in the oil spill cleanup operations. These included abnormal ECGs, ventricular conduction delays, anterior fascicular blocks, sinus rhythm nonspecific T waves, sinus bradycardia ST and T waves, sinus rhythm early repolarizations, and ventricular hypertrophy. Given the age of the cleanup workers, we would not expect to see such findings. Over the long term, these cardiac function abnormalities were decreased slightly as compared to the abnormalities seen during their initial visit. We believe that these slight improvements are due to the muscular repair of this organ over time versus the continued damage of the pulmonary tissues and later scarring. Collectively these findings suggest that intensive participation for only several weeks in oil spill cleanup activities resulted in persistent long-term adverse health effects.

The following limitations should be considered when interpreting the study findings. While our study does provide a longitudinal perspective on hematological and hepatic functions in oil spill cleanup workers, it is limited by its use of only initial and the follow-up evaluations and a sample size as a majority of the subjects elected not to return for a follow-up assessment. The limited sample size may have influenced the statistics of the study findings. The existence of methodological challenges particularly studying dynamic human health effects of the oil spill disaster due to the lack of pre-disaster data is another limitation of this study. As is common in disaster research, in this study we did not have pre-disaster health data for all the oil spill cleanup workers and therefore cannot identify all causal factors for the significant alterations found in the hematological, hepatic, pulmonary, and cardiac functions of the oil spill cleanup workers. However, our inclusion of a comparison group that did not participate in the oil spill cleanup operations allowed us to assess relative differences between the oil spill exposed and unexposed groups during their

initial and 7-year follow up visits after the disaster. While we recognize that measuring oil spill exposure is difficult due to a lack of validated methodologies and tools of the actual exposure amount that each worker received. We believe it is very unlikely that there was much exposure misclassification of the study participants who were involved in the oil spill cleanup activities.

Despite these study limitations, our findings can clearly demonstrate that exposure to an oil spill is associated with both short-term and long-term adverse health effects in workers involved in its cleanup operations. Specifically, the people who participated in the cleanup activities of the BP oil spill experienced persistent alterations or worsening of their hematological, hepatic, pulmonary and cardiac functions, and prolonged illness symptoms that were still present or worsened 7 years after their exposure. These findings further suggest that workers who are involved in oil spill cleanup operations should be followed consistently over time to detect any long-term toxicities of their oil spill exposure. Since the oil spill contained carcinogenic agents, a latent period exists before these worsening symptoms manifest themselves and progress to malignant diseases. Serial periodic health checkups and routine laboratory blood work as well as high-resolution imaging and pulmonary and cardiac function assessments are necessary to monitor the long-term adverse health effects in workers who participate in oil spill cleanup activities to detect any future malignant transformation.

CONCLUSION

The results of this long-term investigation indicate that subjects involved in the BP oil spill cleanup operations experienced persistent alterations in their hematological, hepatic, pulmonary, and cardiac functions. The hematological alterations include increased mean WBC counts, hemoglobin, hematocrit, and reduced platelet counts as well as BUN levels among the oil spill cleanup workers even 7 years after the oil spill disaster. Hepatic

alterations included the increased ALP, AST, and ALT levels in the serum indicate hepatic injury in the workers involved in oil spill cleanup operations. A majority of the oil spill cleanup workers developed chronic rhinosinusitis and reactive airway dysfunction syndrome as new symptoms during their later follow-up visit. The incidence of pulmonary function abnormality in the oil spill exposed workers increased substantially from their initial evaluation to their later follow-up assessment. The cardiac abnormalities that were seen in the initial visit persisted even 7 years after the disaster in most of the oil spill cleanup workers. In addition, the oil spill exposed workers reported prolonged or worsening illness symptoms that were present even 7 years after their initial exposure. Additional studies are being conducted to further understand other long-term potential toxic health effects of the BP oil spill exposure among those workers involved in the Gulf oil spill cleanup operations.

VERIFICATION

All authors listed in the manuscript had access to the data and a role in preparing the manuscript.

ETHICS STATEMENT

The study was approved by the University Cancer Diagnostic Centers Institutional Review Board (Quorum Review IRB). As this study involved the retrospective review of medical records of subjects attending the University Diagnostic Centers as part of an organization database, waiver of informed consent was approved by the Quorum Review Board.

AUTHOR CONTRIBUTIONS

Both authors conceived and the study design; collected, analyzed, and interpreted the data; and drafted and wrote the manuscript. Both authors read and approved the final manuscript.

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